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Plasma Flow in a Multipole Magnetic Channel

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## PLASMA FLOW IN A MULTIPOLE FIELD

The flow of ionized gas (plasma) and its interaction with magnetic fields are basic areas of plasma research. Control of the state of the plasma, its direction of flow, and its purity are among the broad applications of knowledge in these areas. Specifically, this experiment is concerned with measuring the behavior of a plasma as it enters and flows along the "magnetic channel" created by a multipole magnetic field. Measurements will be made to determine changes in the density and energy of the plasma as it moves down the field and to determine local plasma-field interactions, i.e., electric fields, evidence of turbulent flow and loss of particles from the stream.

### SUMMARY AND CONCLUSIONS

The multipole field assembly has been tested for electrical difficulties and vacuum leaks. It proved satisfactory except that the stepdown transformer will not supply full current, but action will be taken to eventually remedy this. A more energetic mode of operation of the conical gun is under study in which hydrogen plasma velocity as high as  $1.45 \times 10^7$  cm/sec will be developed.

### DISCUSSION

The multipole field has been assembled (Fig. 1) and is under test. The system has been vacuum tested to a pressure of  $2 \times 10^{-6}$  torr. on a test vacuum system. Electrical

tests have been carried out using 20 kv capacitors to feed a simple air core transformer consisting of a 110 turn primary and a single turn secondary. Rogowski coil current measurements for a 15 kv capacitor voltage show that 60 ka at a frequency of 1380 cycles is supplied to the multipole field. When we improve the high voltage insulation it should be possible to attain 80 ka at 20 kv charging voltage with this transformer. We expect to improve transformer efficiency to attain the 160 ka design current at a later date.

A more energetic conical gun output has been attained by operating on the second half cycle of gun current and by changing both the delay from activation of the fast gas valve to firing of the gun and changing the pressure of hydrogen gas in the plenum of the gas valve. The optimum delay for our geometry was found to be about 250 microseconds. Directed velocity of the plasma as high as  $1.45 \times 10^7$  cm/sec was attained at a plenum pressure of 30 torr. This corresponds to a directed energy of about 100 eV for hydrogen ions. Higher total energy of the plasma is attained with plenum pressure of about 100 torr.

The magnetic loop measurement technique has been improved by the addition of a compensating loop which provides a  $B_z$  signal which is subtracted from the measuring loop voltage. This permits a more sensitive measure of the diamagnetic plasma signal. Measurements are made by single turn loops around the 10 cm diameter drift tube. All signals are passively integrated before display on oscilloscopes.

A set of magnetic loop measurements is shown in Fig. 2. These measurements are for the higher energy regime discussed earlier. The bank energy is 5100 Joules and the  $B_z$  field strength is 2 kilogauss. These data show an average

longitudinal velocity of  $1.14 \times 10^7$  cm/sec. Qualitative evaluation of the rate at which the plasma spreads in these successive records indicates that the random energy has been increased in this newer mode of gun operation. Analysis of these second half cycle plasma puffs to determine ion temperature and number density is not yet complete, but the smooth appearance and repeatability of these data suggest that they should fit the computational model very well.

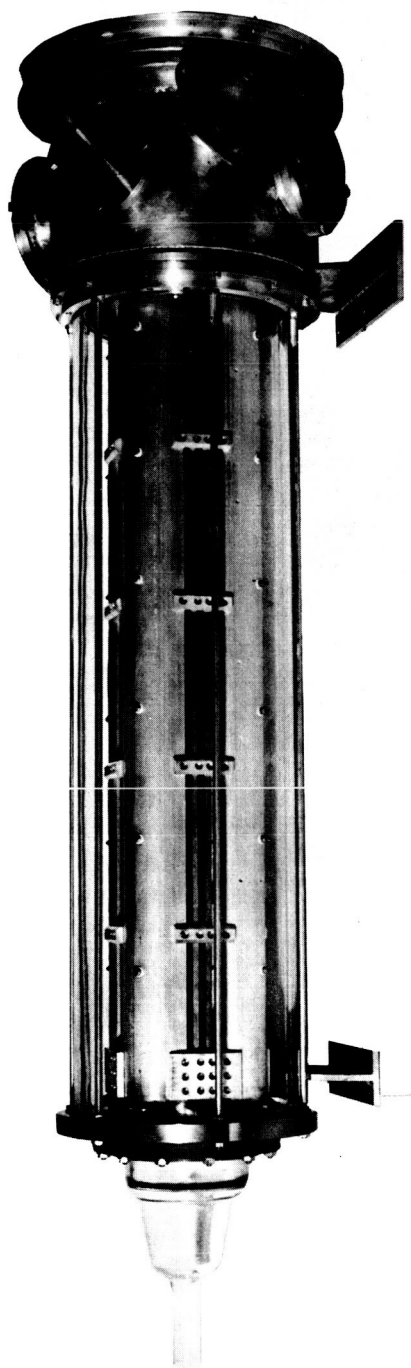


Fig. 1 MULTIPOLE FIELD

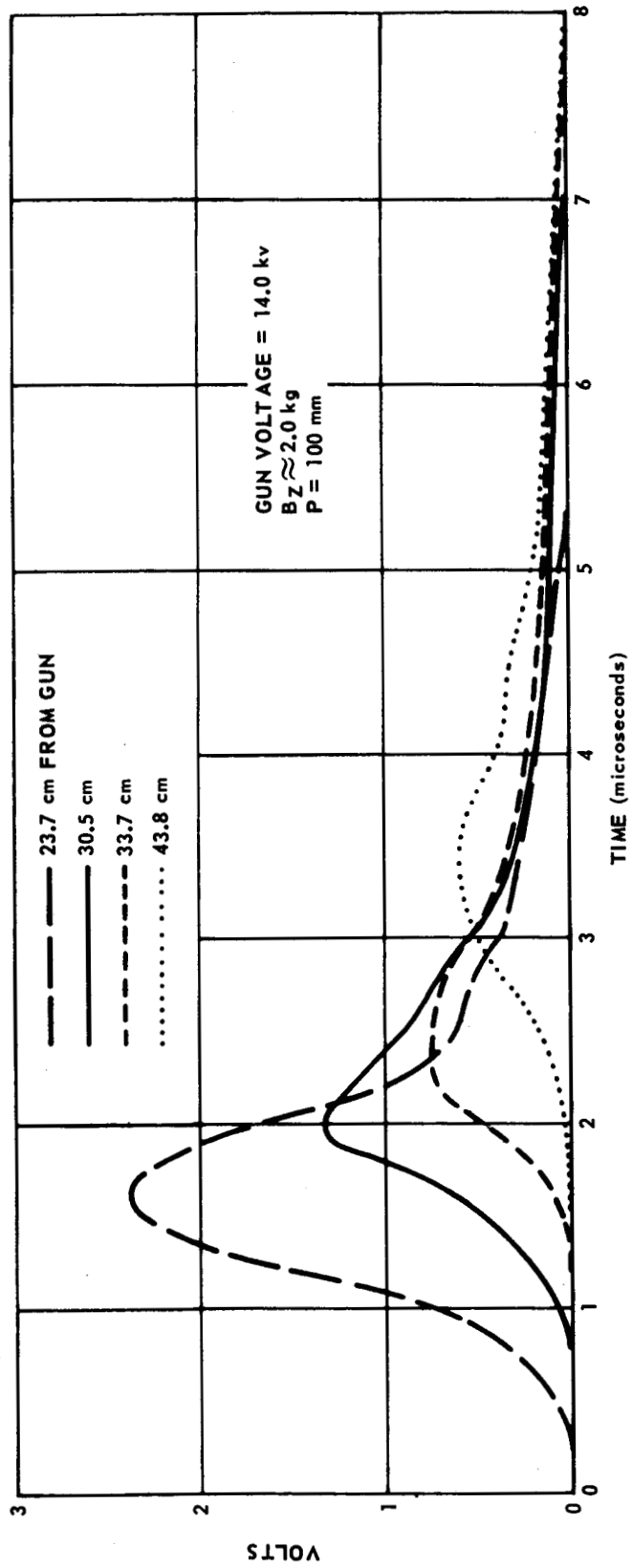


Fig. 2 MAGNETIC LOOP SIGNALS